ISSN : 2583-0910
Agri-India TODAY
visit us at www.agriindiatoday.in

Peer reviewed
monthly newsletter

Article ID : 02/I/01/0122

BIOFERTILIZER-AN OVERVIEW

Amit Phonglosa[1*] and Chongtham Tania[2]
[1]Directorate of Extension Education,
Odisha University of Agriculture and Technology,
Bhubaneswar-751003, Odisha
[2]ICAR Research Complex NEH Region Manipur Centre,
Lamphelpat- 795 004, Manipur
*Corresponding author-Email : soilamit12@rediffmail.com

Introduction

Biofertilizer is a term that can be interpreted in different ways (El-Ghamry *et al.*, 2018; Mącik *et al.* 2020). It is also called microbial inoculants, are organic products containing specific microorganisms, which are derived from plant roots and root zones. According to Kawalekar (2013), biofertilizer improves the growth and yield of the plant by 10-40%. A substance which contains living microorganisms when applied to the soil, a seed or plant surface colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant is called biofertilizer (Vessey, 2003). Biofertilizer is most commonly referred to as selected strains of beneficial soil microorganisms cultured in the laboratory and packed in suitable carriers (Hari and Perumal, 2010). The term biofertilizer may be used to include all organic resources for plant growth which are rendered in available form for plant absorption through microorganisms or plant associations or interactions (Khosro and Yousef, 2012). Biofertlizer started with culture of small scale compost production that has evidently proved the ability of biofertilizer (Khosro and Yousef, 2012). It is recognized when the culture accelerates the decomposition of organic residues and agricultural by products through different processes and gives healthy harvest of crops. The history of biofertilizer began with the start of “Nitragin” by Nobbe and Hilther in 1895.

Advantage of biofertilizers

- Application of biofertilizer increases crop yield by 20-30%, replaces chemical N and P by 25% and also stimulates plant growth. Therefore, it is supplementary to chemical fertilizers.
- It is cost effective relative to chemical fertilizers and low manufacturing costs especially N and P use.
- Organic fertilizers have been known to improve biodiversity (soil life) and long term productivity of soil, and may prove a large depository for excess carbon dioxide.
- It increases the abundance of soil organisms such as fungal mycorrhiza, which help plants in absorbing nutrients.
- It improves soil structure (porosity), water holding capacity and secrete certain growth promoting substances.
- It enhances seed germination.
- It improves soil fertility and fertilizer use efficiency and ultimately the yield of crops.

- Continuous use of biofertilizers for 3–4 years, there is no need for their application, as parental inocula are sufficient for growth and multiplication (Bumandalai and Tserennadmid, 2019)

Limitation of biofertilizers

- Non availability of appropriate and efficient strains of bacteria.
- Lack of suitable carrier, due to which self life is short.
- Marketing of biofertilizer is not easy as the product contains living organisms.
- Shortage and viability of *Vesicular Arbuscular Mycorrhiza* (VAM) inoculum
- Transportation is the major problem during storage of biofertilizers.
- Lack of awareness of farmers.
- Poor and inexperienced staffs.

Different types of biofertilizers

Biofertilizers are grouped into different types based on their mode of action and functions. Microorganisms used as biofertilizer include- Nitrogen fixers e.g. *Azotobacter chroococcum, Cyanobacteria, Rhizobium* sp. and potassium solubilizers e.g. *Bacillus mucilaginous*, phosphorus solubilizers e.g. *Aspergillus fumigatus, Bacillus megaterium,* Plant Growth Promoting *Rhizobacteria* (PGPR), *Vesicular Arbuscular Mycorrhiza* (VAM) e.g., *Glomus mosseae* and sulfur oxidizers (S-oxidizers). In one gram of fertile soil, up to 10^{10} bacteria can be present, with a live weight of 2000 kg ha^{-1} (Raynaud and Nunan, 2014). Soil bacteria could be *cocci* (sphere, 0.5 µm), *bacilli* (rod, 0.5–0.3 µm), or spiral shaped (1–100 µm). The presence of bacteria in the soil mainly depends upon the physical, chemical properties of the soil, organic matter and phosphorus contents, as well as cultural activities. Although, nutrient fixation and plant growth enhancement by bacteria are key mechanisms for achieving sustainable agriculture goals in the future. Different types of biofertilizers based on the type of microbe used and mode of action along with suitable examples are presented briefly in Table-1.

Table 1. Different types of biofertilizers, mechanisms and their groups with examples

Biofertilizers	Mechanism of different biofertilizers	Groups and their examples	Citations
Nitrogen (N) fixing	Increase soil N content by fixing atmospheric N and make it available to the plants	a. Free-living (e.g. *Azotobacter, Anabaena*, *Clostridium, Aulosira, Bejerinkia, Nostoc, Klebsiella, Stigonema, Desulfovibrio, Rhodospirillum* and *Rhodopseudomonas*) b. Symbiotic (e.g. *Anabaena azollae, Frankia, Rhizobium* and *Trichodesmium*) c. Associative symbiotic (e.g. *Azospirillum* spp., *Alcaligenes, Azoarcus* sp. *Acetobacter diazotrophicus, Enterobacter, Herbaspirillum* sp.)	Choudhury and Kennedy, 2004

Biofertilizers	Mechanism of different biofertilizers	Groups and their examples	Citations
Phosphorus (P) solubilizing	Solubilize the insoluble forms of P in the soil into soluble forms by secreting organic acids and lowering soil pH to dissolve bound phosphates	a. Bacteria (e.g. *Agrobacterium, Aereobacter, Bacillus circulans, B. subtilis, B. polymyxa, Flavobacterium, Micrococcus, Pseudomonas striata and Penicillium* sp.) b. Fungi (e.g. *Penicillum* sp., *Aspergillus awamori* and *Trichoderm*a)	Board, 2004
P mobilizing	Transfer P from the soil to the root cortex which are broad spectrum biofertilizers. Some fungi increase the uptake of soluble phosphates.	a. Mycorrhiza (e.g. *Arbuscular mycorrhiza, Acaulospora* spp., *Gigaspora* sp., *Glomus* sp., *Scutellospora* sp. and *Sclerocystis* sp.)	Chang, 2009
Potassium (K) solubilizing	Solubilization of K by producing organic acids that decompose silicates and help in the removal of metal ions and make it available to plants.	**a. Bacteria** (e.g. *Bacillus mucilaginosus, B. circulanscan, B. edaphicus* and *Arthrobacter* sp.) **b. Fungi** (e.g. *Aspergillus niger*)	Etesami *et al.*, 2017
K mobilizing	They mobilize the inaccessible forms of K in the soil.	a. Bacteria (e.g. *Bacillus* sp.) b. Fungi (e.g. *Aspergillus niger*)	Jha, 2017
Micronutrient	Oxidizing sulfur (S) to sulfates which are usable by plants.	a. S oxidizing (e.g. *Thiobacillus* sp.)	Itelima *et al.,* 2018
	Solubilize the zinc (Zn) by chelated ligands, proton, acidification and by oxidoreductive systems.	a. Zn solubilizing (e.g. *Bacillus* sp., *Mycorhiza, Pseudomonas* sp.)	Kamran *et al.,* 2017
Plant growth Promoting (PGP)	A variety of bacteria can develop hormone that promote root growth, increases nutrient availability and help in improvement of crop yield.	PGP rhizobacteria (e.g. *Agrobacterium, Arthrobacter, Bacillus, Enterobacter, Erwinia, Pseudomonas* sp., *Pseudomonas fluorescens, Rhizobium, Streptomyces* and *Xanthomonas*)	Backer *et al.,* 2018

Application of biofertilizers

- Biofertilizers can be applied on seedlings, seeds and directly to the soil.
- Seed treatment is the most common practice of applying biofertilizers due to its simplicity and small amount of product required for inoculation (Asif *et al.,* 2018).

- Inoculants can be applied to the seeds in different ways *i.e.* dusting, slurry and seed coating (Malusa and Ciesielska, 2012).
- Through dusting method, dry seeds are mixed directly with the inoculants. This method may result in weak adherence of microorganisms to the seeds, hence is thought to be least effective.
- With slurry, bio inoculant is mixed with wetted seeds or directly with water and then with seeds. Alternatively, the seeds may be left in the slurry for night (Malusa and Ciesielska, 2012).
- Seed must be coated with the appropriate number of microorganisms adhesives such as gum arabic, carboxy methyl cellulose, sucrose solutions, vegetable oils and non-toxic commercial products are used (Bashan *et al.,* 2014).
- In seed coating method, seeds are mixed with the slurry prepared from the inoculants and then are coated with finely ground inorganic inert materials such as lime, clay, rock phosphate, charcoal, dolomite, calcium carbonate or talc.
- As a result, microorganisms are protected from adverse environmental conditions and from the harmful impact of chemical fertilizers and pesticides (Malusa and Ciesielska, 2012).
- Seed treatment may be conducted with bacteria belonging to the following genus: *Azotobacter, Azospirillum*, phosphorus solubilizing microorganisms (PSM), *Rhizobium* and also with the consortium of microorganisms. Seeds are firstly coated with *Azotobacter* sp. or *Azospirillum* sp. and *Rhizobium* and then, PSM inoculant is added as the outer layer thus the higher number of feasible microbial cells can be maintained (Brahmaprakash *et al.,* 2017).
- Soil treatment facilitates control of the location and the application rate of the inoculants, protects inoculants from the harmful impact of pesticides and fungicides and also avoids damage to the seed coats.
- The soil inoculation increases chance of contacting seeds with the higher concentration of biofertilizer in comparison with seed treatment.
- Generally, soil inoculation with granules has been implemented in developed countries, where advanced machinery and accessories for fertilization are used (Bashan *et al.,* 2014).

Precaution for the use of biofertilizers

- Biofertilizers should also be stored at appropriate temperature, no below 0 °C and over 35 °C.
- Avoid direct exposure to sunlight.
- Away from direct sun or hot wind and store the packets of biofertilizers in cold place.
- Treat the seeds (seed coating) or seedling (dipping) under shade only.
- Avoid direct contact of chemical fertilizers and pesticides.
- Good quality biofertilizer is identified with the moisture content of 30-40%,
- In case of soil application, mix recommended dose of biofertilizer with 50 kg pulverized soil or FYM and broadcast.
- Every biofertilizer responds better if soil is enriched with sufficient quantity of available phosphate (apply super phosphate), organic matter (apply FYM), soil of neutral pH (apply lime).

- To obtain best effect, treatment with biofertilizers is advised 3-4 hour before sowing.

Conclusion

In recent years, biofertilizers have emerged as an important component for biological nitrogen fixation. Biofertilizer offer an economically attractive and ecologically sound route for providing nutrient to the plant. They comprise a promising tool in agricultural ecosystems as a supplementary, renewable and eco friendly source of plant nutrients. As they have an ability to transform nutritionally important elements from non usable to highly assimilable forms without deleterious effects on natural environment, they are an important component of Integrated Plant Nutrient System (IPNS) (Alley and Vanlauwe, 2009). Application of biological fertilizers is thought to be a key element in maintaining soil fertility and crop productivity on the sufficiently high level, indispensable to achieve sustainability of farming. Biofertilizers may also help mitigate difficulty arising from the growing demand of global population for food and from the widespread chemicalization in agro-ecosystems. The changing approach to the agricultural practices makes biofertilizers a vital part of modern day crop production and emphasizes significance of biological inoculants in forthcoming years.

References

Alley, M.M. and Vanlauwe, B. (2009). The Role of Fertilizers in Integrated Plant Nutrient Management. International Fertilizer Industry Association. https://doi.org/10.1016/ B978-0-12-385536-7.00002-9

Asif, M., Mughal, A.H., Bisma, R., Mehdi, Z., Saima, S., Ajaz, M., Masood, A., Malik, M.A. and Sidique, S. (2018). Application of different strains of biofertilizers for raising quality forest nursery. *Int. J. Curr. Microbiol. App. Sci*. 7: 3680–3686. https://doi.org/ 10.20546/ijcmas.710.425

Backer, R., Rokem, J.S., Ilangumaran, G., Lamont, J., Praslickova, D., Ricci, E., Subramanian, S. and Smith, D.L. (2018). Plant growth promoting rhizobacteria: Context, mechanisms of action, and roadmap to commercialization of biostimulants for sustainable agriculture. *Front. Plant Sci.* 9: 1473.

Bashan, Y., De-Bashan, L.E., Prabhu, S.R. and Hernandez, J.P. (2014). Advances in plant growth-promoting bacterial inoculant technology: formulations and practical perspec- tives (1998-2013). *Plant and Soil* 378: 1–33. https://doi.org/10.1007/s11104-013- 1956-x.

Board, N. (2004). *The Complete Technology Book on Bio-Fertilizer and Organic Farming*; National Institute of Industrial Research: Delhi, India.

Brahmaprakash, G.P., Sahu, P.K., Lavanya, G., Nair, S.S., Gangaraddi, V.K. and Gupta, A., (2017). Microbial functions of the rhizosphere. In: Singh, D.P. (Ed.), Plant-Microbe Interactions in Agro-Ecological Perspectives. Springer Nature Singapore Pte Ltd, pp. 177–210. https://doi.org/10.1007/978-981-10-6593-4.

Bumandalai, O. and Tserennadmid, R. (2019). Effect of Chlorella vulgaris as a biofertilizer on germination of tomato and cucumber seeds. *Int. J. Aquat. Biol*. 7: 95–99.

Chang, C.H. and Yang, S.S. (2009).Thermo-tolerant phosphate-solubilizing microbes for multi-functional biofertilizer preparation. Bioresour. Technol. 100: 1648–1658.

Choudhury, A. and Kennedy, I. (2004). Prospects and potentials for systems of biological nitrogen fixation in sustainable rice production. *Biol. Fertil. Soils*, 39: 219–227.

El-Ghamry, A.M., Mosa, A.A., Alshaal, T.A. and El-Ramady, H.R. (2018). Nanofertilizers vs. biofertilizers: new insights. *Environ. Biodiv. Soil Security* 2: 1–22. https://doi.org/10.21608/jenvbs.2018.3880.1029

Etesami, H., Emami, S. and Alikhani, H.A. (2017). Potassium solubilizing bacteria (KSB): Mechanisms, promotion of plant growth, and future prospects A review. *J. Soil Sci. Plant Nutr.* 17: 897–911.

Hari, M. and Perumal K. (2010). Booklet on Bio-fertilizer (phosphabacteria). Shri Annm Murugapa Chettiar Research Centre Taramani Cheninai. 1-6.

Itelima, J., Bang, W., Onyimba, I. and Oj, E. (2018). A review: Biofertilizer; a key player in enhancing soil fertility and crop productivity. *J. Microbiol. Biotechnol. Rep.* 2: 22–28.

Jha, Y. (2017). Potassium mobilizing bacteria: Enhance potassium intake in paddy to regulates membrane permeability and accumulate carbohydrates under salinity stress. *Braz. J. Biol. Sci.* 4: 333–344.

Kamran, S., Shahid, I., Baig, D.N., Rizwan, M., Malik, K.A. and Mehnaz, S. (2017). Contribution of zinc solubilizing bacteria in growth promotion and zinc content of wheat. *Front. Microbiol.* 8: 2593.

Kawalekar, J.S.(2013). Role of biofertilizers and biopesticides for sustainable agriculture. *J. Bio. Innov.* 2: 73–78.

Khosro, M. and Yousef, S. (2012). Bacterial bio-fertilizers for sustainable crop production: A review APRN *Journal of Agricultural and Biological Science*. 7(5): 237-308.

Mącik, M., Gryta, A. and Frąc, M. (2020). Biofertilizers in agriculture: An overview on concepts, strategies and effects on soil microorganisms. *Advances in Agronomy. https://doi.org/10.1016/bs.agron.2020.02.001*

Malusa, E. and Ciesielska, J. (2012). Biofertilizers: a resource for sustainable plant nutrition, in: fertilizer technology. *Synthesis* 1: 282–320.

Raynaud, X. and Nunan, N.(2014). Spatial ecology of bacteria at the microscale in soil. *PLoS ONE*, 9: e87217.

Vessey, J.K. (2003). Plant growth promoting Rhizobacteria as bio-fertilizers. *Journal of Plant and Soil.* 225(43): 571-86.